MACHINES AND MECHANISMS 1.2

Machines are devices used to alter, transmit, and direct forces to accomplish a specific objective. EX. A chain saw is a familiar machine that directs forces to the chain with the objective of cutting wood.

A mechanism is the mechanical portion of a machine that has the function of transferring motion and forces from a power source to an output. It is the ***heart of a machine***. For the chain saw, the mechanism takes power from a small engine and delivers it to the cutting edge of the chain.

A mechanism can be considered rigid parts that are arranged and connected so that they produce the desired motion of the machine. The purpose of the mechanism in Figure 1.2 is to lift the platform and any objects that are placed upon it.

FIGURE 1.2 Adjustable height platform (Courtesy Advance Lifts).

KINEMATICS

It is the study of the geometry of motion.

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Kinematic analysis involves determination of

1-*position*, 2- *displacement*,3- *rotation*, 4-*speed*, 5-*velocity*, and 6-*acceleration of a mechanism*.

A joint is a movable connection between links and allows relative motion between the links. The two primary joints, also called full joints, are the revolute and sliding joints. The revolute joint is also called a pin or hinge joint. It allows pure rotation between the two links that it connects. The sliding joint is also called a piston or prismatic joint. It allows linear sliding between the links that it connects. Figure 1.4 illustrates these two primary joints.

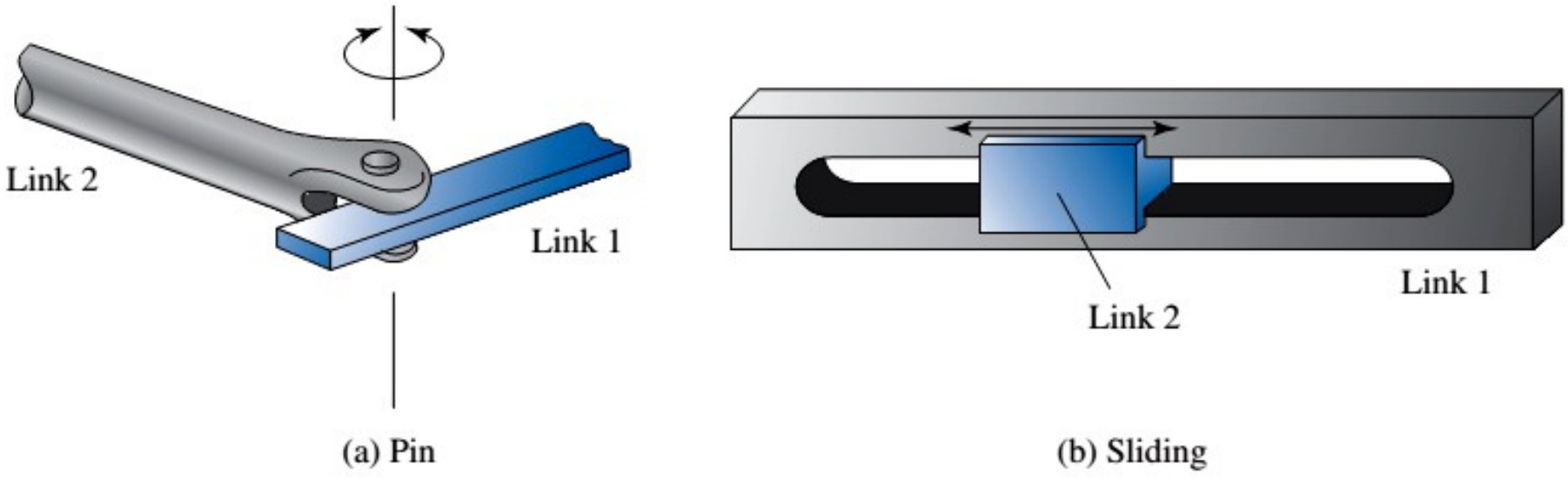


FIGURE 1.4 Primary joints: (a) Pin and (b) Sliding.

A cam joint is shown in Figure 1.5a. It allows for both rotation and sliding between the two links that it connects. Because of the complex motion permitted, the cam connection is called ***a higher-order joint***, also ***called half joint***. A gear connection also allows rotation and sliding between two gears as their teeth mesh. The gear connection is also a ***higher-order joint***.

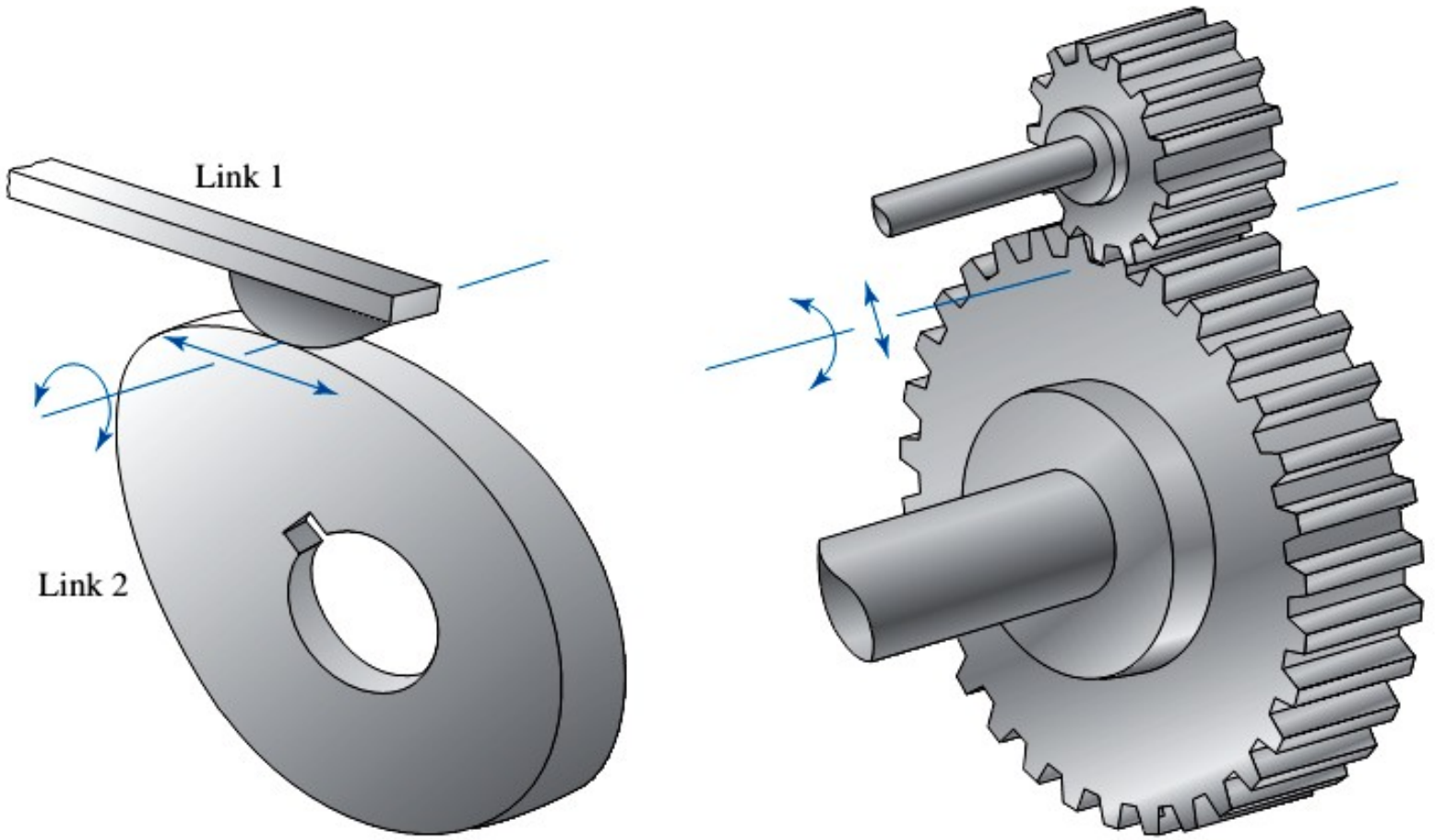
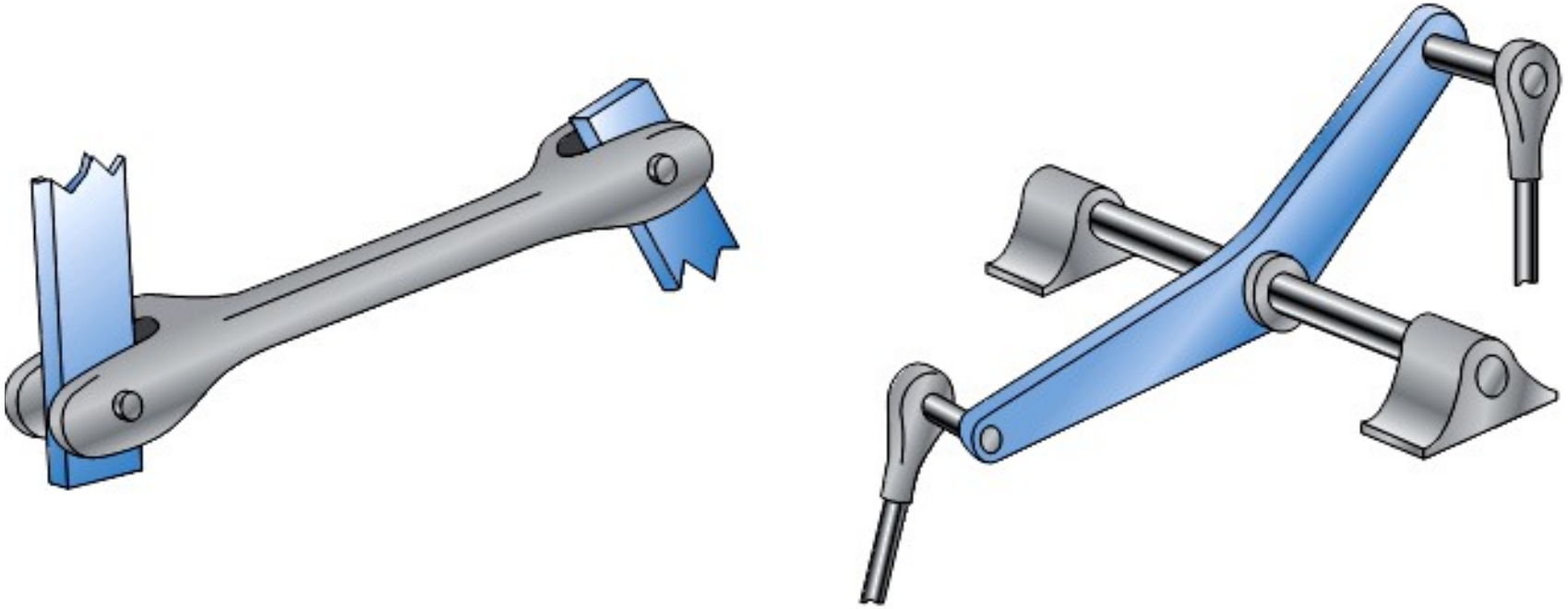


FIGURE 1.5 Higher-order joints: (a) Cam joint and (b) Gear joint.

A simple link is a rigid body that contains only two joints, which connect it to other links. Fig 1.6a illustrates a simple link. A crank is a simple link that is able to complete. A crank is a simple link that is able to complete a full rotation about a fixed center.



(a) Simple link (b) Complex link

FIGURE 1.6 Links: (a) Simple link and (b) Complex link.

.A complex link is a rigid body that contains more than two joints

A rocker is a simple link that oscillates through an angle, reversing its direction at certain intervals.

TABLE 1.1 Symbols Used in Kinematic Diagrams

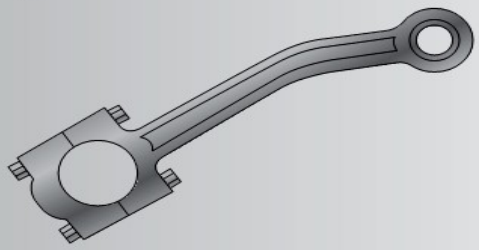
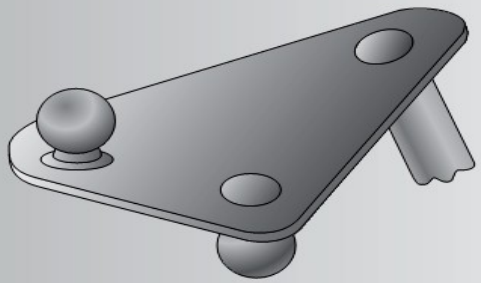
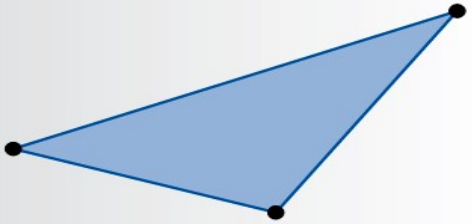
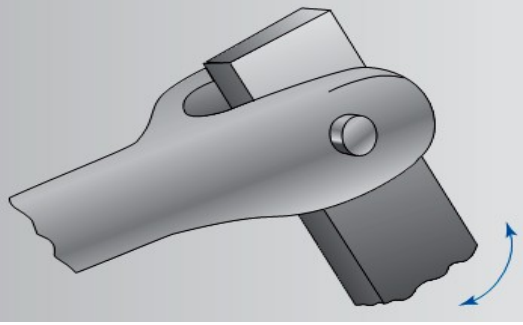
Component	Typical Form	Kinematic Representation
Simple Link		
Simple Link (with point of interest)		
Complex Link		
Pin Joint		

TABLE 1.1 (Continued)

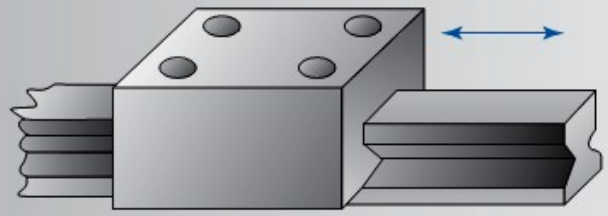
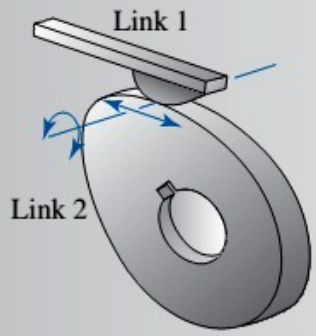
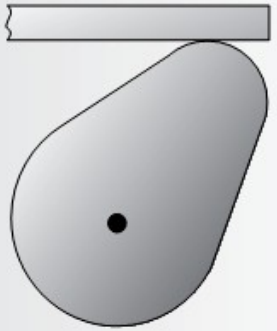
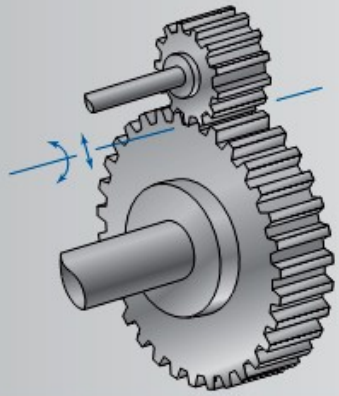
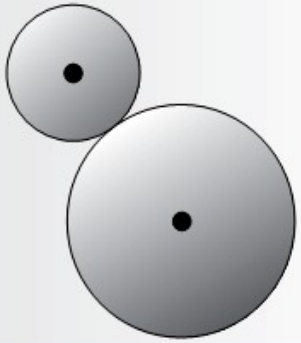
Component	Typical Form	Kinematic Representation
Slider Joint		
Cam Joint		
Gear Joint		

Figure 1.9 shows a shear that is used to cut and trim electronic circuit board laminates. Draw a kinematic diagram.

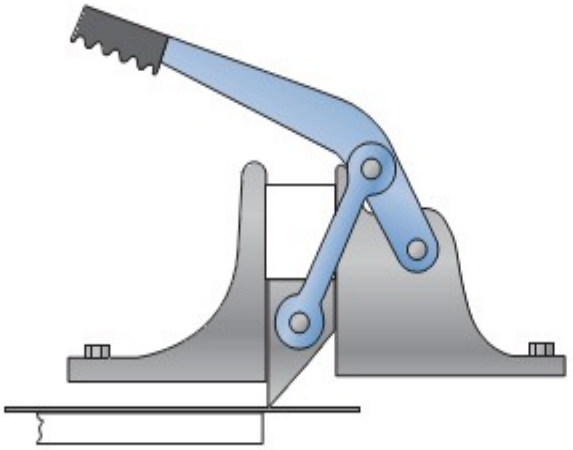


FIGURE 1.9 Shear press for Example Problem 1.1.

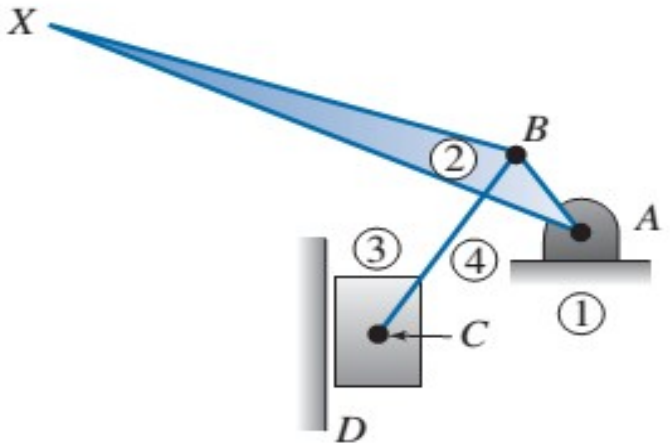


FIGURE 1.10 Kinematic diagram for Example Problem 1.1.

EXAMPLE PROBLEM 1.2

Figure 1.11 shows a pair of vise grips. Draw a kinematic diagram.

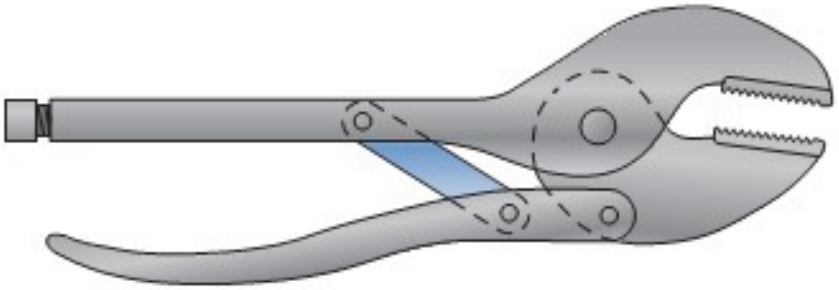


FIGURE 1.11 Vise grips for Example Problem 1.2.

5. ***Draw the Kinematic Diagram***

The kinematic diagram is given in Figure 1.12.

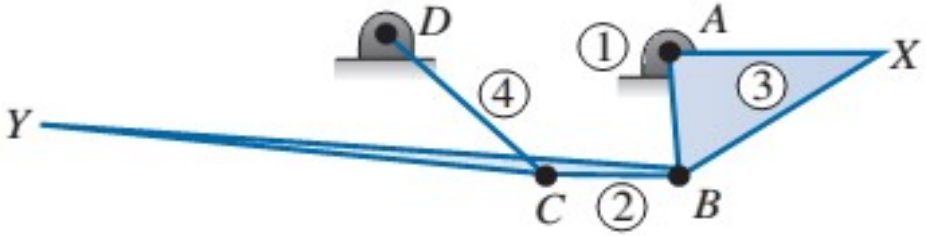


FIGURE 1.12 Kinematic diagram for Example Problem 1.2.

Figure 1.14 shows a toggle clamp. Draw a kinematic diagram, using the clamping jaw and the handle as points of interest. Also compute the degrees of freedom for the clamp.

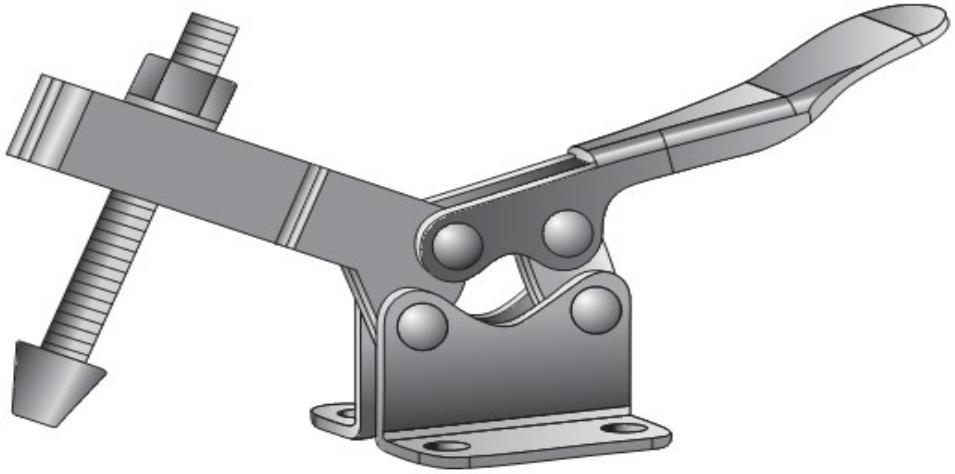


FIGURE 1.14 Toggle clamp for Example Problem 1.3.

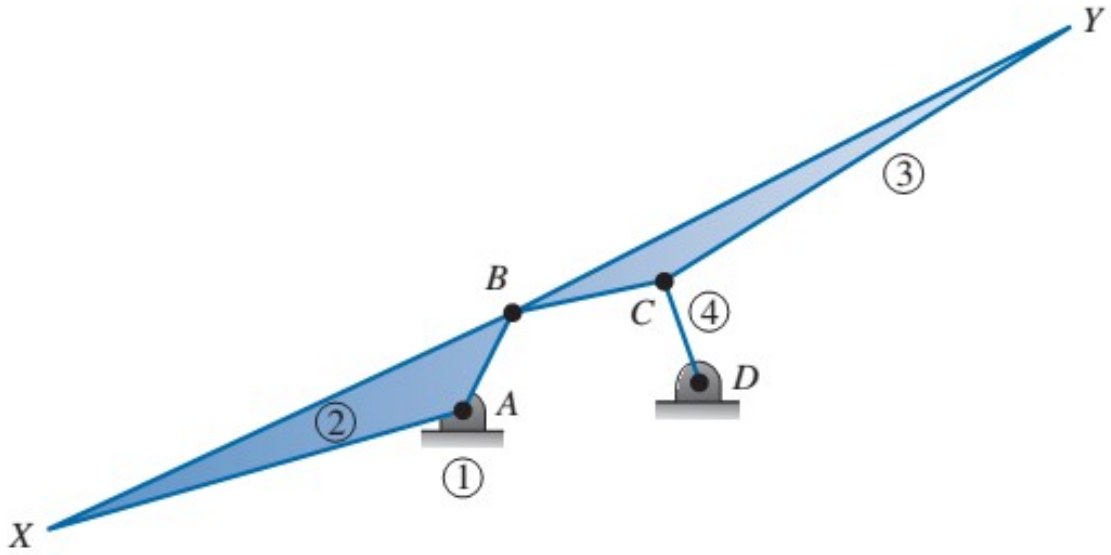


FIGURE 1.15 Kinematic diagram for Example Problem 1.3.

Gruebler's Equation

$$M = \text{degrees of freedom} = 3(n - 1) - 2j_p - j_h$$

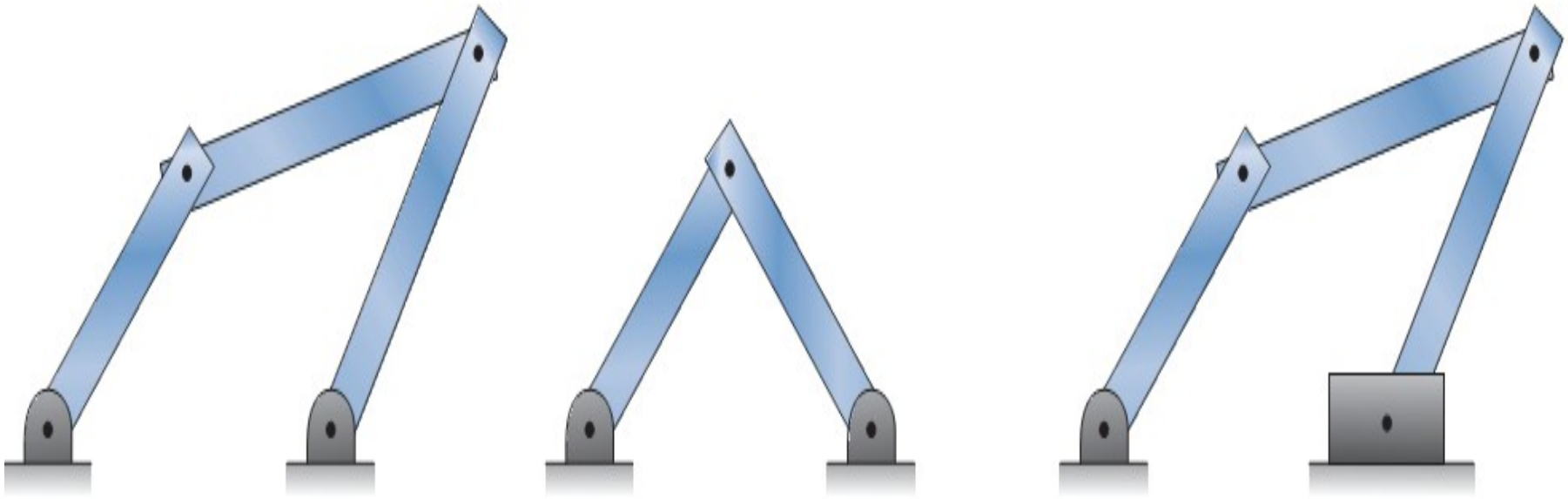
where:

n = total number of links in the mechanism

j_p = total number of primary joints (pins or sliding joints)

j_h = total number of higher-order joints (cam or gear joints)

Linkages with zero, or negative, degrees of freedom are termed locked mechanisms.



(a) Single degree-of-freedom ($M = 1$) (b) Locked mechanism ($M = 0$) (c) Multi-degree-of-freedom ($M = 2$)

FIGURE 1.13 Mechanisms and structures with varying mobility.

Figure 1.16 shows a beverage can crusher used to reduce the size of cans for easier storage prior to recycling. Draw a kinematic diagram, using the end of the handle as a point of interest. Also compute the degrees of freedom for the device.

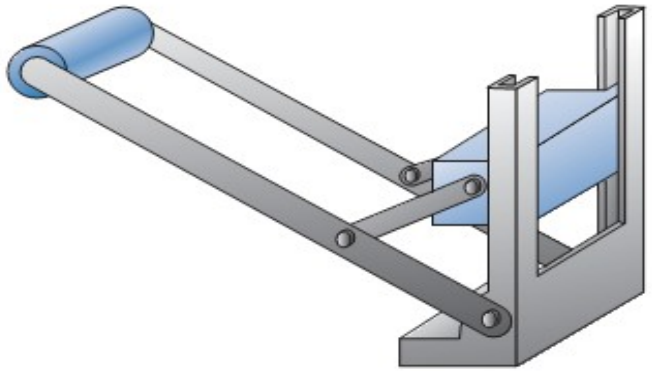


FIGURE 1.16 Can crusher for Example Problem 1.4.

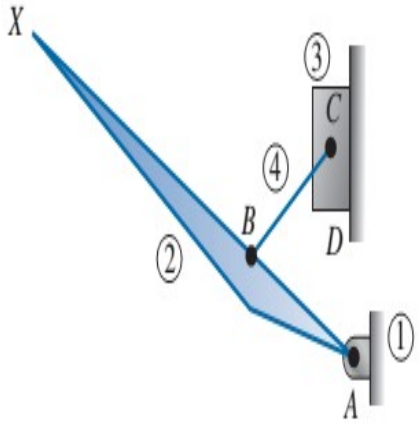


FIGURE 1.17 Kinematic diagram for Example Problem 1.4.

Calculate Mobility

It was determined that there are four links in this mechanism. There are also three pin joints and one slider joint. Therefore,

$$n = 4, j_p = (3 \text{ pins} + 1 \text{ slider}) = 4, j_h = 0$$

and

$$M = 3(n - 1) - 2j_p - j_h = 3(4 - 1) - 2(4) - 0 = 1$$

With one degree of freedom, the can crusher mechanism is constrained. Moving only one link, the handle, precisely positions all other links and crushes a beverage can placed under the crushing block.

Figure 1.18 shows another device that can be used to shear material. Draw a kinematic diagram, using the end of the handle and the cutting edge as points of interest. Also, compute the degrees of freedom for the shear press.

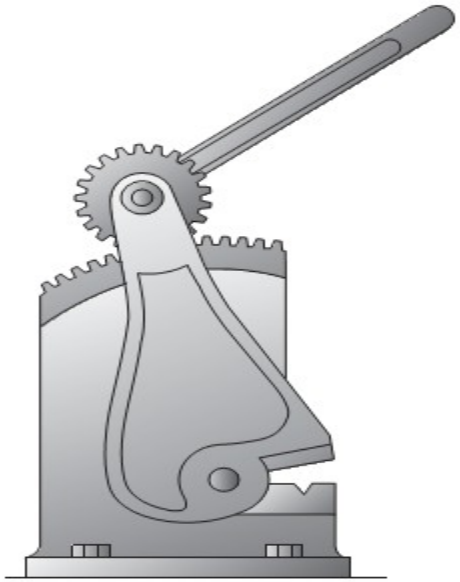


FIGURE 1.18 Shear press for Example I

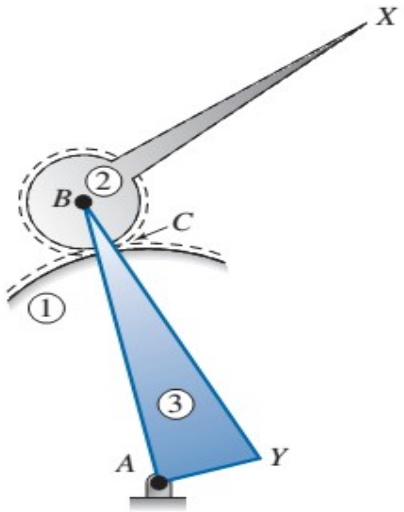


FIGURE 1.19 Kinematic diagram for Example Problem 1.5.

To calculate the mobility, it was determined that there are three links in this mechanism. There are also two pin joints and one gear joint. Therefore,

$$n = 3 \quad j_p = (2 \text{ pins}) = 2 \quad j_h = (1 \text{ gear connection}) = 1$$

and

$$M = 3(n - 1) - 2j_p - j_h = 3(3 - 1) - 2(2) - 1 = 1$$

With one degree of freedom, the shear press mechanism is constrained. Moving only one link, the handle, precisely positions all other links and brings the cutting edge onto the work piece.